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Before The
FEDERAL COMMUNICATIONS COMMISSION

Washington, D.C. 20554

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FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF SECRETARY

In the Matter of

Revision of the Commission's
rules to ensure compatibility
with enhanced 911 emergency
calling systems

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CC Docket No. 94-102

DOCKET FILE COPY ORIGINAL

To: The Commission

**COMMENTS OF THE ASSOCIATED GROUP, INC.
ON NOTICE OF PROPOSED RULEMAKING**

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SUMMARY

Associated RT, Inc. ("ART") strongly supports the Commission's efforts to ensure that mobile radio subscribers have the same access as wireline callers to 911 emergency services. As the Commission recognizes, a key aspect of achieving this result is the implementation of an automatic location information ("ALI") requirement on wireless systems. In the event a wireless 911 caller is unable to identify his/her whereabouts, ALI may provide emergency service personnel with critical information which could make the difference between life and death.

In meetings held by industry and the public safety community ("Joint Expert Meeting" or "JEM"), the JEM participants found that, with respect to emergency services for wireless callers, implementing an ALI requirement is a top priority. ART urges the Commission to adopt the conclusions and recommendations reached by the JEM participants and articulated in the Joint Expert Meeting reports.

As the industry leader in cellular telephone location technology, ART's research and testing demonstrates that ALI is technically and economically feasible. ART has developed and patented an automatic location system which it calls TruePosition™. The TruePosition Location System is a passive overlay to a cellular, PCS, or ESMR network utilizing time difference of arrival ("TDOA") technology. Ongoing testing should conclusively demonstrate the ability to locate 90% to 95% of transmissions with an accuracy of better than 400 to 500 feet.

In addition to enhancing the ability of emergency personnel to assist wireless 911 callers, location information will also provide new revenue producing and cost saving opportunities for cellular operators (i.e., billing by location and anti-fraud applications). Thus, ART believes that ALI technology will be embraced by wireless operators because it provides value-added capabilities that wireless operators can sell to customers.

ART believes that ALI systems, including TruePositions, will be commercially available for volume shipment by mid-1996. Thus, in adopting rules specifying an ALI requirement for wireless services, ART suggests that the Commission link the ALI implementation schedule to the anticipated date of commercial availability. This will ensure that the benefits of advanced ALI systems reach the public as soon as possible.

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**COMMENTS OF THE ASSOCIATED GROUP, INC.
ON NOTICE OF PROPOSED RULEMAKING**

Pursuant to Sections 1.415 and 1.419 of the Commission's rules,¹ Associated RT, Inc. ("ART"), a wholly owned subsidiary of The Associated Group, Inc. ("Associated"), by its attorneys, submits these Comments in response to the Notice of Proposed Rulemaking in CC Docket 94-102 ("Notice").²

I. INTRODUCTION

The Commission states that the primary objective of this Notice is to "ensure broad availability of 911 and enhanced 911 services to users of the public switched network ("PSTN") whose health and safety may depend on 911 emergency services systems."³

¹47 C.F.R. §§ 1.415, 1.419.

²Revision of the Commission's Rules to Ensure Compatibility with Enhanced 911 Emergency Calling Systems, Notice of Proposed Rulemaking, CC Docket 94-102, FCC 94-237, 59 Fed. Reg. 54828 (rel. Oct. 19, 1994).

³Notice at ¶1.

Countless Americans have grown to depend on 911 services in emergency situations. However, the Commission correctly recognizes that "wireless 911 services [as currently configured] are inferior to the wireline 911 services that telephone users have come to expect."⁴

In light of the dramatic growth in the number of mobile service subscribers, and the critical function that 911 services fulfill in our society, ART strongly supports the Commission's effort to adopt rules requiring wireless services to make enhanced 911 services available to mobile radio callers. As the industry leader in cellular telephone location technology, ART will focus on the Commission's proposals regarding user location information and its compatibility with wireless services.

II. ART SUPPORTS THE ADOPTION OF AN AUTOMATIC LOCATION INFORMATION REQUIREMENT ON WIRELESS SYSTEMS FOR 911 SERVICES

On June 30, 1994, a number of industry and public safety groups issued an "Emergency Access Position Paper" ("Joint Paper"), which presented recommendations regarding the development of appropriate standards for emergency access from wireless service systems.⁵ Based largely on the findings contained in the Joint Paper, the Commission believes that wireless systems should have the ability to identify the location

⁴Notice at ¶10.

⁵Notice at ¶35.

of a wireless terminal used to make a 911 call.⁶ Because an approximate geographic location "may be of minimal use to emergency service personnel," the Commission recognizes the need for precise geographic location information, including not only "the latitude and longitude of the mobile unit, but also its elevation in the event the caller is located in a high-rise building."⁷ ART agrees with the Commission's conclusion. In the event a wireless 911 caller is unable to identify his/her whereabouts, precise automatic location information ("ALI") may provide emergency service personnel with critical information which could make the difference between life and death.

The importance of ALI is also acknowledged in reports issued following two Joint Experts Meetings ("JEM") held in August and October of 1994.⁸ The November JEM Report lists, in priority order, Public Safety Answering Point ("PSAP") service requirements with respect to wireless services. The top three priorities, as identified by industry experts and the public safety community are as follows:

⁶Notice at ¶45.

⁷Notice at 45.

⁸See Notice at ¶48. A primary function of the JEM was to define and prioritize emergency service call taker features for wireless systems. See "Emergency Services," TR45 Joint Experts Meeting Report (August 24, 1994) [hereinafter "August JEM Report"]. See also "Wireless Support of 9-1-1 and Enhanced 9-1-1 Emergency Services," Joint Experts Meeting Report (November 2, 1994) [hereinafter "November JEM Report"]. It should be noted that JEM participants included those parties responsible for the Joint Paper (APCO, NASNA, NENA and PCIA) upon which the Commission relied in developing the proposals included in the Notice.

1. Emergency Services Reached by dialing 9-1-1
2. 9-1-1 Call Priority (over other non-emergency call originations)
3. **Identify Caller's Initial Location⁹**

The high priority of ALI speaks volumes about its relative importance to 911 emergency procedures. In further defining automatic location service requirements, the November JEM Report recommends that --

- * Obtaining location information shall not require overt action on the part of the caller
- * The method of sending location information from the wireless system to the emergency service system shall be standardized. The location information describing the mobile station's position should have a data stream format that will allow the following data elements to be presented:
 - Latitude
 - Longitude
 - Altitude
 - Resolution
 - Accuracy
 - Geometric Description
 - Confidence Level
 - Motion Information
 - Time Stamp
 - Source of caller's geographic location
 - a. Mobile Station ("MS")
 - b. Base Station Controller ("BSC")
 - c. Mobile Switching Center ("MSC")
 - d. Home Location Register ("HLR")
 - e. Selective Router ("SR")
- * Location information should be obtainable for all 9-1-1 callers
- * Accuracy Goals:
 - Near term goal: within 400 feet (longitude, latitude, resolution)
 - Long term goal: within 40 feet (longitude, latitude, altitude, resolution)¹⁰

⁹November JEM Report at 6-7 (emphasis added).

¹⁰November 2, 1994 JEM Report at 7-8.

The Commission, recognizing the work of the JEM in the Notice, stated: "These efforts will help to ensure that the rules finally adopted in this proceeding are as effective and efficient as possible."¹¹ ART supports the JEM recommendations unconditionally, and urges the Commission to craft its rules in a manner that will give life to these objectives.

Significantly, the Commission states in the Notice that "we do not anticipate adopting extensive technical standards for enhanced 911 operation ... we propose that general performance criteria be adopted."¹² ART believes that this is the correct path. The Commission should not be in the position of choosing any specific technology, thereby selecting "winners and losers." As the Commission is aware, numerous location systems exist or are being developed.¹³ By adopting performance guidelines as set forth in the November JEM Report, industry participants will be able to tailor their specific location systems to meet the needs of the 911 caller. The technology "winner" will be the one that best meets the performance guidelines in an efficient and cost effective manner.¹⁴

¹¹Notice at ¶48.

¹²Notice at ¶40.

¹³A copy of a "Survey of Location Technologies to Support Mobile 9-1-1," conducted by C. J. Driscoll & Associates (October 11, 1994) has been placed in the record of this proceeding. See Notice at ¶47.

¹⁴In fact, there will likely be more than one "winner." There is a class of ALI technical approaches that can be implemented at wireless base station sites which do not require
(continued...)

Most recently, in its Personal Communications Services proceeding, the Commission adopted a flexible technical framework for the design and implementation of PCS systems.¹⁵ The Commission specifically found that while mandating detailed technical standards for the provision of PCS could provide certain benefits, the "imposition of a rigid technical framework at [this nascent stage of development] may stifle the introduction of important new technology [Accordingly, we] find that the flexible approach ... is the most appropriate approach."¹⁶ Location systems are also at an early stage of development and should be afforded the same technical flexibility.

Moreover, in Personal Communications Services, the Commission directed the wireless industry and standards-setting bodies to focus attention on offering an emergency 911 capability that would work with enhanced 911 systems.¹⁷ As the Commission knows, industry representatives and the public safety community

¹⁴(...continued)
modifications of wireless handsets or subscriber units (e.g., time difference of arrival, direction-finding). Within this class, different approaches may be better suited to different local conditions. Wireless operators may select alternative methods from within this class while still supporting interoperability and achieving other public interest goals. Accordingly, the Commission should not specify a single ALI technology as a national standard.

¹⁵Amendment to the Commission's Rules to Establish New Personal Communications Services, Second Report and Order, GEN Docket 90-314, 8 FCC Rcd 7700 (1993) at ¶135.

¹⁶Id. at ¶137.

¹⁷Id. at ¶139.

have already begun address these issues.¹⁸ ART urges the Commission to allow these efforts to continue.

III. ART'S AUTOMATIC LOCATION INFORMATION TECHNOLOGY FOR WIRELESS SYSTEMS IS TECHNOLOGICALLY AND FINANCIALLY VIABLE

In the Notice, the Commission seeks comment on the specific technical and cost considerations affecting the implementation of a detailed ALI requirement.¹⁹ Based on its own extensive experience with ALI technology, ART firmly believes that the JEM recommendations are technically possible, and can be implemented in a financially viable manner.

ART began researching ALI technologies in 1992,²⁰ and has since assembled a team of experts to evaluate and test various ALI alternatives. As a result of this research, ART has developed and patented an ALI technology which it calls "TruePosition".²¹ The TruePosition Location System is a passive

¹⁸"We are aware that the industry is working with the public safety community to address many of the same issues that we are addressing in this proceeding, particularly with regard to ALI." Notice at ¶48.

¹⁹Notice at ¶46.

²⁰For a discussion of the benefits and drawbacks of alternative location technologies, see Stilp, "Examining the Coming Revolution in Location Services," Wireless Communications Forum, Volume II, Number 3 at 56 (December 1994) ("Stilp"). Mr. Stilp is the general manager of location services for The Associated Group, Inc. (formerly Associated Communications Corporation), ART's parent company. A copy of this article is attached hereto as Exhibit 1.

²¹United States Patent Number: 5,327,144 (issued July 5, 1994). A copy of this Patent is attached hereto as Exhibit 2.

overlay to a cellular, PCS, or ESMR network that "listens" to bursty messages occurring on the reverse control channel (or similar radio channel), and uses time difference of arrival ("TDOA") techniques to calculate the geographic position, direction of travel, and velocity of a transmitter. This location information is available in real time, or on a store-and-forward basis, to emergency services operators.

TDOA operates by precisely timing the reception of a telephone's radio signal at many antenna locations, and then calculating the differences in time of arrival. Although the location system antennae may frequently be placed at existing cell sites, this is not generally a requirement. The location system requires more sensitive and wider bandwidth receivers than are typically used in cellular system base stations. Additionally, for maximum precision, the location system requires antenna locations that have very wide visibility; current cellular systems, particularly in congested urban areas, use down-tilted and sectorized antennae that limit visibility for maximum frequency reuse. Antenna configurations with wide visibility enable True Position to capture independently call information such as telephone number, ESN, and called number (i.e., 911) in addition to calculating location, direction of travel, and velocity.

A typically configured TruePosition Location System is expected to locate 90% to 95% of transmissions with an accuracy

of better than 400 to 500 feet.²² The remaining transmissions may be located with accuracies ranging from 500 feet to several miles. It is important to remember, however, that the location of radio signals is a statistical process, with accuracy highly dependent on the configuration and deployment of location system antennae at appropriate sites.²³

ART estimates that its TruePosition location system will cost system operators, on average, between \$25,000 - \$45,000 per cell site, to be installed on approximately 2/3 of all cell sites in a system.²⁴ This cost estimate compares favorably with the cost of implementing cellular digital packet data ("CDPD") technology.²⁵ In fact, TruePosition will cost less than CDPD (which is now being widely deployed in cellular systems) because the equipment needed is receive only.

Significantly, a TDOA approach such as TruePosition does not

²²More specifically, ART believes that it will be able to achieve the following accuracy goals:

90% of 911 calls located to 500 feet accuracy or better
75% of 911 calls located to 375 feet accuracy or better
50% of 911 calls located to 250 feet accuracy or better

²³See Stilp at 62-64 for a more detailed discussion of the accuracy of location devices.

²⁴TruePosition will typically be installed at "coverage" cell sites (*i.e.*, cells built for the purpose of increasing the footprint of a cellular system) but not at "capacity" cell sites (*i.e.*, cells built for the purpose of adding additional voice channels within an existing footprint).

²⁵The cost of implementing CDPD has been estimated at approximately \$50,000 per cell site. See K. Miller, "CDPD: The Carriers Come Through," Data Communications, Vol. 73, No. 13 at 21 (September 21, 1994).

require any modification to the wireless handset or subscriber unit. This distinguishes it from ALI systems that must receive special transmissions, such as Global Positioning System signals or FM radio station subcarriers, or require other handset modifications or augmentations in order to calculate location. These systems would require the modification of the more than 23 million cellular subscriber units now in use. By requiring specialized equipment only at a relatively few fixed locations throughout an area, a TDOA approach will be far less expensive to implement because there are no additional incremental costs per subscriber.

ART's initial interest in ALI technology was not for 911 purposes, but from the perspective of a cellular carrier seeking new business applications such as billing by location and anti-fraud measures.²⁶ ART remains confident that location information will provide opportunities for cellular carriers to enhance revenue and decrease costs and firmly believes that ALI will be embraced by wireless operators because it provides a value-added capability that wireless operators can sell to customers. Among the new revenue producing/cost saving services that wireless operators will be able to offer are:

- * more efficient operations for fleets of vehicles;
- * a highly reliable stolen vehicle tracking service;

²⁶Associated Communications Corporation (predecessor to The Associated Group) held authorizations in four cellular markets in upstate New York. These authorizations were transferred to Southwestern Bell Wireless Holding, Inc. as of December 15, 1994.

- * a "billing by location" service, whereby (for example) a shopping mall operator could pay the cost of calls made while shopping at the mall, as a promotional tool;²⁷

- * combating wireless phone fraud (although calls from cloned cellular phones can be identified by analyzing calling patterns, catching cellular pirates is difficult because the pirate has unlimited mobility).²⁸

In sum, ART believes that imposing an ALI requirement for E911 will not be a significant cost burden for operators because E911 capability will be a value-added for a technology that is already cost effective. Based on data from the testing described below, ART intends to make its TruePosition location system commercially available to cellular operators by the mid-1996.

A. Rochester, NY TruePosition Prototype Test

TruePosition was first tested as a "laboratory prototype" using four antennae in the Cellular One system in Rochester, NY from March 1993 to February 1994. The purpose of the test was

²⁷A number of cellular operators offer their customers discount calling plans for calling within a sub-area of the larger Cellular Geographic Service Area. For example, they are able to differentiate and bill calls made within a single area code. The billing by location service possible with ART's technology will facilitate much more refined calling plans tailored on a customer-by-customer basis.

²⁸The Cellular Telephone Industry Association ("CTIA") estimates that fraud costs the cellular industry approximately \$1 million per day. See Communications Daily, Volume 14, Number 202 at 6 (October 14, 1994). Thus, it is interesting to consider that eliminating fraud alone could pay for national system deployment of TruePosition in just one-year.

limited to verifying that the TDOA approach would operate in the cellular bands using the narrow bandwidth signals cellular systems emit, and to demonstrating its effectiveness to potential customers and manufacturers. The system demonstrated an accuracy of 225 feet RMS ("root mean square") for a stationary telephone visible to all four antennae, and an accuracy of 550 feet RMS for a vehicle driving on a variety of roads throughout a 50 square mile area of Rochester.²⁹ The results of ART's Rochester test mirror work done by George L. Turin on automatic vehicle-monitoring ("AVM").³⁰

B. Philadelphia, PA TruePosition Alpha Test

The second TruePosition system will be installed, in cooperation with Comcast Cellular Communications, at 6 cell sites in Philadelphia, PA in January 1995, and will be operated until May 1995. The system is expected to cover approximately 40 square miles just north of Center City and Interstate 676. The primary purpose of this system is to test major refinements to TruePosition's hardware and software architecture and algorithms, and to verify system operation in the high multipath environment

²⁹The difference in accuracy was caused by poorer visibility to the antennae, multipath, and other factors.

³⁰See Turin, Jewell and Johnston, "Simulation of Urban Vehicle-Monitoring Systems" IEEE Transactions on Vehicular Technology, Vol. VT-21, No. 1, February 1972 ("Turin"). Using computer simulations of the radiolocation subsystem, the Turin study found that AVM systems in which locational data are acquired by radiolocation techniques are feasible even in the worst urban multipath propagation environments. A copy of this paper is attached hereto as Exhibit 3.

of a major cellular market. ART expects that the Philadelphia market has a variety of conditions that can be used to simulate conditions in other dense markets such as New York, Chicago, and Los Angeles. The system's goals will remain at 500 foot accuracy for 90% to 95% of the transmissions.

The system will be capable of locating a cellular telephone on any single 30 KHz channel. Most of the engineering testing will be conducted using a portable cellular telephone operating on a dedicated channel set aside for testing purposes. Any other phone can be located, however, if the channel number is known a priori. After technical testing during January through March, ART will make the system available for demonstrations to interested parties, including wireless industry officials, public safety administrators and Commission staff. The testing should conclusively demonstrate the ability to locate existing cellular telephones to within 500 feet in an urban environment in the horizontal direction.³¹

C. Greater Philadelphia TruePosition Beta Test

Beginning in September 1995 and continuing through November 1995, ART plans to install a beta version of the TruePosition system at 20 cell sites, with testing scheduled to conclude in March 1996. The target testing areas are currently planned for

³¹Once this technology is perfected in two dimensions, ART will incorporate vertical location capability into its system. The ability to obtain vertical location information is a function of antenna placement.

New Jersey and Pennsylvania. Although exact testing areas have not been determined, ART hopes to cover approximately 50 miles of the New Jersey Turnpike and approximately 30 miles of the Pennsylvania Turnpike (subject to availability of adequate antenna locations). ART will apprise the Commission of the testing area once these details are finalized. The system will be near production quality and speed, and will be capable of locating any cellular telephone dialing 911. The system's goals will remain at 500 foot accuracy for 90% to 95% of the transmission.

The purpose of the beta test will be a full application test for testing both public safety application technology, as well as business applications including billing by location. ART hopes and intends to interface the location system with the New Jersey State Police and to comparable Pennsylvania organizations. For emergency services support, the system will locate any caller dialing "911" or "*911" and will pass to the emergency service provider (i) calling and called numbers, (ii) time stamp and channel number, (iii) geographic location in latitude, longitude coordinates, (iv) speed and direction of travel, and (v) the resolution and confidence interval associated with the location estimate. This information can be routed to any desired device.

IV. THE COMMISSION'S THREE STEP AUTOMATIC LOCATION INFORMATION IMPLEMENTATION SCHEDULE IS UNNECESSARILY COMPLEX

Because of technical and financial uncertainty, the Commission tentatively concluded that compliance with ALI requirements should occur in three stages.³² In the first stage, wireless service providers would be required to design their systems so that the location of the base station or cell site (and the direction of the mobile unit from the base station) receiving a 911 call from a mobile unit is relayed to the closest PSAP. This requirement would take effect one year after the effective date of the order adopting such a rule.

While there are benefits to immediately connecting a 911 caller to the closest PSAP, this interim measure would not help in directing public safety personnel to the scene of an emergency when the caller cannot provide an exact location. Conversely, this immediate connection takes on less importance in situations where the caller can identify his/her location. Moreover, implementing this first stage could require E911 PSAP design changes (such as data base designs or information display layouts needed, for example, to record and show the caller's direction from a base station site) that would be employed only during this relatively short first stage and replaced at stage two.

Thus, ART contends that time and resources would be better spent moving directly to the implementation of a location system that is able to identify the latitude, longitude, and, where

³²Notice at ¶49.

appropriate, the altitude of the caller. In short, ART believes that the Commission's proposed "first stage" is of marginal utility and should be rejected as unnecessary.

During the proposed second stage (scheduled to commence three years after the effective date of these rules), the Commission would require that ALI information provided to the PSAP include an estimate of the approximate location and the distance of the mobile unit from the receiving base station or cell site. ART supports this requirement and believes that it will serve as a valuable interim measure while the initial location information systems are being refined.

In the proposed third and final stage of ALI implementation, the Commission would require that the mobile station be located in a 3-dimensional environment within a radius of no more than 125 meters.³³ ART believes that this objective can be achieved, and encourages the Commission to adopt such a requirement for mobile systems.

The Commission has suggested a relative timeframe for ALI implementation, with each stage tied to the effective date of the

³³As with all measures of performance in mobile systems, both accuracy and reliability must be taken into account. The "125 meters" is a measure of accuracy. Multipath, blockage, and other propagation phenomena, will make it impossible to achieve this accuracy 100% of the time. ART believes that a reliability measure of 90% is appropriate for ALI systems, i.e., ALI systems should achieve an accuracy of 125 meters at least 90% of the time. The Commission commonly uses reliability measures in establishing regulations for radio-based services. See Sections 73.683 and 73.684 of the Commission's Rules (addressing TV field strength contours and coverage based on F(50, 50) curves). 47 C.F.R. §73.683 and 47 C.F.R. §73.684.

rules. However, because ALI systems are likely to be commercially available for volume shipments as early as mid-1996, this schedule could cause unnecessary delay. Instead, the Commission should link its ALI implementation schedule to the anticipated date of commercial availability so that the benefits of more advanced systems reach subscribers expeditiously.

In sum, ART suggests that the Commission simplify its proposed ALI implementation schedule by (1) eliminating stage one; (2) directing wireless services to meet approximate ALI goals not later than three years from the time ALI systems first become commercially available; and (3) requiring precise location information capability not later than five years from the time ALI systems first become commercially available.

V. CONCLUSION

In light of the critical role that 911 and E911 services play in our society, ART strongly supports the Commission's efforts to ensure that mobile radio subscribers have the same access as wireline callers to emergency services. Toward this end, ART encourages the Commission to adopt the conclusions and recommendations reached by industry and the public safety community and articulated in the Joint Expert Meeting reports.

As the Commission is aware, the JEM participants found that requiring automatic location capability is a key component in ensuring that wireless callers have access to the same level of emergency services available to wireline callers. ART research

and testing demonstrates that ALI is technically and economically feasible. Accordingly, while permitting the market to decide which technology will best achieve the objectives specified in the JEM reports, ART urges the Commission to adopt rules specifying the adoption of an ALI requirement for wireless services.

Respectfully submitted,

**ASSOCIATED RT, INC., A SUBSIDIARY
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January 9, 1994

EXHIBIT 1

Examining the Coming Revolution in Location Services

Louis A. Stilp

Louis Stilp is the general manager of location services for Associated Communications Corporation. Associated has examined and tested location systems in its New York state cellular markets since 1992.

Someone awakening from a ten-year slumber might be overwhelmed by the advances in wireless communications. Business plans of ten years ago projecting one million cellular subscribers by the year 2000 have long been discarded, made obsolete by dramatic improvements in wireless growth, performance, prices, and new products. But if anyone has grown comfortable with this progression and dares to begin another ten-year nap, he or she might again find that a decade of revolution had occurred — in wireless location services.

It is inevitable that carriers must have the ability to locate every wireless device. This inevitability could be validated just by the growth in emergency calls from wireless phones. In the United States, Emergency 911 (E-911) systems have the mandate to provide high levels of emergency services to anyone in need.

Great efforts have been expended on building databases that can associate an address with each landline telephone. Thus, a distressed or disoriented caller can be located quickly. The same level of service is not available to wireless callers, even though such callers now represent about 25 percent¹ of all emergency 911 calls placed today. This issue is being addressed by Joint Expert Meetings held under the auspices of the Telecommunications Industry Association, and in a Notice of Proposed Rulemaking announced by the FCC² in September 1994. The collective efforts of these organizations are expected to result in a requirement that wireless service providers, including cellular and Personal Communications Services (PCS) carriers, build location technologies into their networks and/or mobile devices within a few years. This will enable E-911 dispatch centers to offer an equivalent level of service to both landline and wireless callers.

Because of the need to uniformly implement public policy, it is expected that the location technology for E-911 services will require support for all existing analog wireless telephones, as well as new digital cellular and PCS mobile units. Additionally, it is expected that mobile phone users will not be required to take any action (for example, modifying their older mobile phones) in order to be located. These requirements imply that the location technology choice for this application must work with existing wireless signals.

Billing by Location also is becoming an increasingly important application for wireless carriers to support. Today, most wireless customers are familiar with the two-dimensional rate plans offered by carriers. The two dimensions of these plans are: the expected usage type, ranging from occasional calling plans to high-volume business plans; and time of day, such as peak and off-peak periods.

Billing by Location will permit wireless carriers the additional flexibility to offer new rate choices to their customers. For example, in any plan type and any time of day, a carrier can choose to offer different rates for using the wireless telephone in a home, in an office, on the road, or even in a mall.

This is an attractive opportunity for many carriers for several reasons. Of all mobile devices, cellular telephones represent approximately 15 percent of all telephone numbers in use in the United States, yet they carry less than one percent of all minutes of voice traffic handled. The reason for this usage pattern is not call quality. Cordless telephones and cellular telephones generally have equivalent call quality, yet cordless telephones carry many more minutes of voice traffic per month³.

The reason for lower cellular minutes of use is more likely price per minute. Because of the extensive mobility it offers, wireless service is generally priced at a premium compared to standard landline service. Therefore, most users do not use wireless telephones in their homes if a landline telephone is available. But as the cost of wireless calls has declined, minutes of carried voice traffic have increased. This pricing hypothesis has been tested by several carriers that now offer "off-peak, unlimited" calling plans that permit volume calling for consumers during the off-peak hours for a low average per minute rate. Billing by Location will further increase the flexibility of carriers to offer attractive rate plans to their subscribers, possibly allowing competition with cordless and landline telephones in the home.

Thus, Billing by Location permits carriers an opportunity to increase usage of their networks by offering new services to existing subscribers. It is generally less expensive for any company to sell new services to existing customers than to acquire new customers. These new services may be offered with minimal effect on the carrier's network infrastructure, since even at peak hours only 15 percent to 20 percent of all voice channels are engaged at any point in time.

Fraud Detection and Prosecution is an important and sensitive issue for carriers. Telecommunications fraud has existed for decades in many forms, but in recent years it has become particularly troublesome for wireless carriers because of mobile unit cloning.⁴ Sophisticated algorithms are used by almost every major carrier to analyze calling patterns in real time to detect fraud and identify cloned telephone numbers, but catching perpetrators in the act is difficult because wireless service permits unlimited mobility. A location system that uses existing wireless signals could greatly assist law enforcement authorities. Once a number has been identified as having been cloned, the location system could lead authorities to the perpetrator.

The last key application for location services is System Planning and Design for wireless systems. This is important because capital expenditures typically represent the second largest cash expense item for a carrier. In the early days of cellular, very large cells were constructed with wide coverage areas. Frequency planning was straightforward because the frequency re-use was fairly low.

Today, however, cell sites are smaller in diameter, there are greater numbers of them, and the frequency re-use is very high. Since the spectrum available to wireless is not expanding, wireless system designers spend a tremendous amount of effort in frequency re-use planning and adjusting in order to prevent interference and crosstalk while still providing high quality coverage. Today, the planning is typically theoretical, and once implemented is verified through limited testing. One important element missing from this planning is that designers never really know where wireless devices are located when a specific cell site is handling the call. Today, they can only guess.

With a system that could identify the location of all callers and match those locations to the cell sites that handled the calls and to the received signal power level, system planners could dramatically improve their ability to design cells and wireless systems. Cells could be better positioned and tuned and radio channel usage could be more efficient. Even control channel usage for "paging"⁵ could be significantly improved. Use of location technology for this application would result in higher quality systems at lower implementation cost.

Up Front Considerations

Though it is inevitable that companies have the ability to locate every wireless device, the technology they use to accomplish this may vary by their and users' needs and requirements. Carriers should consider the following issues before choosing a technology:

- Accuracy requirements
- Location update rate
- Changes to the mobile unit
- Power consumption in the mobile unit
- Where the location data is stored
- User action required for obtaining location information.